

## DESCRIPTION

FLOW CELL AND PARTICLE MEASURING APPARATUS USING THE SAME

## 5 Technical Field

[001] The present invention relates to a flow cell for flowing sample fluid therethrough to detect light scattered by particles contained in the sample fluid when irradiated with light so as to obtain information such as a particle diameter, and also relates to a particle measuring apparatus using the flow cell.

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## Background Art

[002] A flow cell 100 used for a conventional particle measuring apparatus as shown in FIG. 6(a) is made of a transparent member, and provided with a linear passage 100a having a predetermined length, the cross-sectional shape of which is rectangular. Also, the shape of the flow cell is an L-shaped tube as a whole. The central axis of the linear passage 100a substantially corresponds with the axis of receiving scattered light  $L_s$  by a condenser lens system 101 (See Japanese Patent Application Publication No. 11-211650). Incidentally, reference number 102 refers to a laser light source, and reference number 103 refers to a photoelectric transducer element.

[003] 20 In the flow cell 100 used for a conventional particle measuring apparatus, inner walls b, c, d, and e unpreferably limit the path of light scattered  $L_s$  by particles passing through a particle monitoring area M, and the condensing angle of the condenser lens system 101 cannot be fully utilized.

[004] In order to make the level of detecting scattered light  $L_s$  so as to improve the accuracy of detecting particles, it is necessary to fully utilize the condensing angle of the condenser lens system 101.

[005] 25 The present invention was made to solve the above-mentioned drawbacks, and the object of the present invention is to provide a flow cell which can detect scattered light more efficiently by fully utilizing the condensing angle of a condenser means, and

also a particle measuring apparatus using the flow cell.

#### Disclosure of the Invention

[006] For solving the above-mentioned drawbacks, according to an aspect of the  
5 present invention, there is provided a flow cell in which a particle monitoring area is  
formed within the flow cell by irradiating with light, and light scattered by particles  
contained in sample fluid passing through the particle monitoring area is condensed by a  
condenser means so as to obtain information including a particle diameter, wherein  
10 inner walls are provided such that the light scattered by particles is condensed in a state  
where the condensing angle of the condenser means is fully utilized.

[007] According to another aspect of the present invention, there is provided a  
particle measuring apparatus comprising the above-mentioned flow cell, a light source  
for irradiating sample fluid flowing through the flow cell to form the particle monitoring  
area, and an optical detecting and processing means for detecting and processing light  
15 scattered or diffracted by particles in the particle monitoring area.

#### Brief Description of the Drawings

[008] FIG. 1 is a perspective view of the first embodiment of a flow cell according to  
the present invention;

[009] 20 FIG. 2 (a) is a sectional view seen from direction A of FIG. 1 and FIG. 2 (b) is a  
sectional view seen from direction B of FIG. 1;

[010] FIG. 3 is a perspective view of the second embodiment of a flow cell according  
to the present invention;

[011] FIG. 4 (a) is a sectional view seen from direction C of FIG. 3 and FIG. 4 (b) is a  
25 sectional view seen from direction D of FIG. 3;

[012] FIG. 5 shows a schematic structure of a particle measuring apparatus according  
to the present invention; and

[013] FIG. 6 (a) shows a schematic structure of a conventional particle measuring  
apparatus, FIG. 6 (b) is a longitudinal sectional view of a conventional flow cell, and

FIG. 6 (c) is a cross-sectional view of the conventional flow cell.

#### Best Mode for Carrying Out the Invention

[014] Preferred embodiments of the present invention will now be described with  
5 reference to the accompanying drawings.

[015] FIG. 1 is a perspective view of the first embodiment of a flow cell according to  
the present invention, FIG. 2 (a) is a sectional view seen from direction A of FIG. 1 and  
FIG. 2 (b) is a sectional view seen from direction B of FIG. 1, FIG. 3 is a perspective  
view of the second embodiment of a flow cell according to the present invention, FIG. 4  
10 (a) is a sectional view seen from direction C of FIG. 3 and FIG. 4 (b) is a sectional view  
seen from direction D of FIG. 3, and FIG. 5 shows a schematic structure of a particle  
measuring apparatus according to the present invention.

[016] As shown in FIGS. 1 and 2, the flow cell 1 of the first embodiment is made of  
a transparent member, and provided with a passage 2 for flowing sample fluid  
15 therethrough in a direction of the arrow so as to form a particle monitoring area M with  
respect to laser light La, and another passage 3 having two exits at both ends which is  
perpendicular to the passage 2 and located between the passage 2 and a condenser lens  
L.

[017] The passage 2 is comprised of four inner walls 2a, 2b, 2c, and 2d, and the cross  
20 section is made rectangular. The passage 3 is also comprised of four inner walls 3a, 3b,  
3c, and 3d, and the cross section is made rectangular.

[018] The particle monitoring area M is formed in a position where the four inner  
walls 2a, 2b, 2c, and 2d of the passage 2 do not hinder scattered light Ls from entering  
the outmost periphery portion of the condenser lens L for condensing the scattered light  
25 Ls so as to fully utilize the condensing angle of the condenser lens L.

[019] As shown in FIG. 2 (a), both ends of the passage 3 are opened, and thereby a  
portion of the inner wall c in the linear passage 100a shown in FIG. 6 (b) which limits  
the path of scattered light Ls is removed. Consequently, the scattered light Ls is not  
hindered from entering the outmost periphery portion of the condenser lens L.

[020] In addition, as shown in FIG. 2 (b), the distance between the inner wall 3c and the inner wall 3d is arranged to be greater than the distance between the inner wall 2c and the inner wall 2d so as not to hinder scattered light Ls from entering the outmost periphery portion of the condenser lens L by the inner walls 3c and 3d.

[021] 5 In the above-mentioned flow cell 1 of the first embodiment, scattered light Ls generated by particles contained in sample fluid passing through the particle monitoring area M can be condensed in a state where the condensing angle  $\theta$  of the condenser lens L is fully utilized.

[022] Incidentally, in the first embodiment, both ends of the passage 3 are opened so as to form exits. However, it is also possible to open only one end of the passage 3 and close the other end. In this case, the inner wall for closing the other end must be arranged so as not to hinder scattered light Ls from entering the outmost periphery portion of the condenser lens L.

[023] Next, as shown in FIGS. 3 and 4, the flow cell 10 of the second embodiment is made of a transparent member, and provided with a passage 11 having a cross section of a rectangle shape, a passage 12 of a pyramidal shape, a passage 13 having a cross section of a rectangle shape, a passage 14 having a pyramidal shape, and a passage 15 having a cross section of a rectangle shape. The particle monitoring area M is formed within the passage 13 by irradiating sample fluid flowing through the passage 13 in a direction of the arrow with laser light La.

[024] The passage 13 is arranged to have a cross-sectional area and a length such that a particle monitoring area M having a desired size can be formed. The passages 11 and 15, and the passages 12 and 14 are positioned so as to be symmetrical with respect to the center of the passage 13, respectively.

[025] 25 In addition, as shown in FIG. 4, four inner walls 14a, 14b, 14c, and 14d of the passage 14 are formed so as not to hinder scattered light Ls from entering the outmost periphery portion of the condenser lens L. With this, the condensing angle  $\theta$  of the condenser lens L for condensing the scattered light Ls can be fully utilized.

[026] In the above-mentioned flow cell 10 of the second embodiment, scattered light

Ls generated by particles contained in sample fluid passing through the particle monitoring area M can be condensed in a state where the condensing angle  $\theta$  of the condenser lens L is fully utilized.

[027]               Incidentally, in the second embodiment, the passages 12 and 14 are made in a  
5       pyramidal shape. However, a conical shape is also possible. Also, another condenser lens may be provided in the opposite position with respect to the flow cell 10 so as to double the condensing angle  $\theta$ .

[028]               It is not essential that all portions of the flow cells 1 and 10 are made of a transparent material. It is possible to form the portions where light does not pass with  
10       a non-transparent material. In addition, it is not essential that the flow cells 1 and 10 are formed as a unitary member. The same function can be achieved by combining a plurality of members.

[029]               Next, as shown in FIG. 5, the particle measuring apparatus according to the present invention is comprised of the flow cell 1, a laser light source 20, a condenser  
15       lens system 21 including the condenser lens L, and a photoelectric transducer element 22. The flow cell 10 shown in FIG. 3 can be used instead of the flow cell 1.

[030]               The particle monitoring area M is formed by irradiating a predetermined area of the passage 2 of the flow cell 1 with laser light La from the laser light source 20. The optical axis of the laser light La is substantially perpendicular to the central axis of  
20       the passage 2 within the passage 2.

[031]               The condenser lens system 21 has an optical axis which corresponds to the central axis of the passage 2, and condenses scattered light Ls generated by particles which has been irradiated with the laser light La in the particle monitoring area M. Incidentally, the condenser lens system 21 does not always need to be positioned in the  
25       central axis of the passage 2.

[032]               The photoelectric transducer element 22 is provided in the optical axis of the condenser lens system 21, and receives the scattered light Ls which has been condensed by the condenser lens system 21 so as to transduce the scattered light Ls into voltage depending on the intensity. The condenser lens system 21 and subsequent elements

are referred to as an optical detecting and processing means.

[033] In operation, a predetermined area of the passage 2 is irradiated with laser light La which has been emitted from the laser light source 20 so as to form a particle monitoring area M. When particles contained in sample fluid pass through the particle monitoring area M, the particles are irradiated with the laser light La and scattered light Ls is generated.

[034] The scattered light Ls is condensed by the condenser lens system 21 toward the photoelectric transducer element 22 in a state where the condensing angle of the condenser lens system 21 is fully utilized due to the shape of the passages 2 and 3. Next, the scattered light Ls which has been condensed toward the photoelectric transducer element 22 is transduced into voltage depending on the intensity of the scattered light Ls.

[035] Since the shape of the passages 2 and 3 is arranged such that the condenser lens system 21 can condense the scattered light Ls toward the photoelectric transducer element 22 in a state where the condensing angle  $\theta$  is fully utilized, the detection level can be improved.

#### Industrial Applicability

[036] As mentioned above, according to an aspect of the present invention, scattered light generated by particles contained in sample fluid passing through the particle monitoring area can be condensed in a state where the condensing angle of the condenser means is fully utilized.

[037] According to another aspect of the present invention, since the shape of the passage of the flow cell is arranged such that optical detecting and processing means can condense the scattered light in a state where the condensing angle is fully utilized, the detection level can be improved.